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COMPARISON OF SOIL TEMPERATURE DATA OBTAINED FROM DIFFERENT KINDS OF SOIL

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COMPARISON OF SOIL TEMPERATURE DATA OBTAINED FROM DIFFERENT KINDS OF SOIL

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ABSTRACT. Six types of soil ranging from sand to clay, with and without vegetation, were investigated. Results showed that greatest differences (in soil) were found in summer; looser soils warm and cool faster, vegetation hinders warming and moisture content is the most consistent regulator of soil temperature. Only bare soils present truly comparable values.

We must consider three important attributes as basic agents in the establishment of temperatures in different kinds of soil: /96*

1. The absorptive capacity of the soil.
2. The capacity of the soil to conduct heat.
3. The specific heat of the soil (its volume capacity).

The warming and cooling of soil are extremely complex processes. Various soils take up as much heat from the sunshine striking them as the heat absorption capacity of their surfaces allows. The same amount of heat received warms soils of different specific heat or volume capacity to a different degree. The three properties mentioned above (heat absorption, heat conductivity, specific heat) as regulating heat distribution in soils are not constant. The moisture and texture of the soil modify all three properties to a considerable extent. Consequently we can say that it is mostly the amount of moisture which regulates soil temperature. Heat loss accompanying evaporation, also dependent upon soil texture, augments the role played by moisture.

By soil texture we mean the way the grains of various size and shape are associated with one another. Thus we can speak of soils of a natural or compact, crumbly or loose structure.

*Numbers in the margin indicate pagination in the foreign text.

The larger and smaller grains or lumps of the soil touch each other and form irregular interstices. If we examine clods of earth carefully, we find they are made of grains of greater or lesser adhesion with one another. Between these we again find gaps, so-called capillary passages.

We find little air in compact soil, while loose soil contains air passages in addition to capillary passages. There are many stages of soil between those of a compact or natural nature and those of a loose or porous nature, and therefore the capacity of the soil to conduct heat, and consequently the warming of soil, is extremely varied. Still, we must recognize the fact that compact soil is warmer in its warmer layers in summer and colder in winter than is loose soil. Fluctuations in the temperature of compact soil take place faster than in loose soil. The surface of loose soil gets warmer than that of compact soil, but the head does not penetrate so deeply.

In addition to variations in soil texture, the vegetation growing upon a soil also has a strong effect upon its heat economy. The vegetation covering with its screening effect prevents the sunshine from striking the soil, thus interfering with the heating process and lessening heat transmission. The screening effect also has a moderating influence on soil water evaporation.

We have established that there are eighteen different kinds of soil within our country. We have selected six of these types where soil temperature measurements can be made and where the data can be prepared.

The comparison is slightly disrupted by the fact that the soil of the selected spots is not completely bare or completely covered with vegetation, but has both conditions. Therefore we took advantage of the opportunity to deal with the effect produced by biological factors.

We selected the sites in such a way that there would be many places for measuring each soil and in consideration of the fact that six different regions blanket the country. These are the sections northwest of the Danube (Sopronhorpacs), southwest of the Danube (Lengyel), the central area between the Danube and the Tisza rivers (Kecskemet), the far south (Baja), the Alfold northeast of the Tisza (Kisvarda) and the southeast beyond the Tisza (Mezohegyes).

In selecting the types of soil we tried to make sure that the most common types were involved. Thus:

Sopronhorpacs:	Soil composed of brick clay (covered with vegetation)
Lengyel:	Clayey forest humus (covered with vegetation)
Kecskemet:	Humus sandy soil (bare)
Baja:	Brown, windblown sand (bare)
Kisvarda:	Brown open country sand (covered with vegetation)
Mezohegyes:	Soil composed of brick clay (covered with vegetation).

In general the covering is a mown turf. The types of soil defined are characterized by the following:

Brick clay soil (Sopronhorpacs): this belongs to the group of soils which can be molded. Usually it is precipitated from the silt found in flooded rivers. It is poorly ventilated. It is characterized by slow heating and cooling and thus has little temperature fluctuations.

Clayey forest humus (Lengyel): this belongs to the forest soil group. The existence of a fairly large forest is usually necessary for its formation. The strong humus salts formed in the leaf mold covering break down the alkaline substances in the soil which are thus washed into the subsoil by rain. Brown forest soil is formed in a less rainy climate. This kind of forest soil formed in a less rainy climate. This kind of forest soil is leached to a lesser extent in the upper layers of soil. As a result of flooding, sedimentation comes into existence.

Properties: except for the upper layer, it absorbs water poorly and retains it well. It is poorly ventilated.

Humus sandy soil (Kecskemet): sandy soils are of a very extensive class. Different from other classes of soil, their humus content is greater than 20%, which also modifies the soil texture. Their texture consists of rough grains and their color is yellowish brown.

Properties: depending on their humus content, their water absorption capacity ranges from good to better. Their water retention capacity is small, their ventilation good, and their temperature range large.

Brown windblown sand (Baja): windblown sand, and thus in general brown windblown sand, is characterized by a completely loose texture formed of large grains. Without any cohesive material, free movement of the upper layers is typical, whether in places exposed to the wind or in the case of scanty vegetation.

It has good water absorption properties but poor water retention. It is very well ventilated with fast heating and cooling on the surface and a large range of heat fluctuation.

Brown open country sandy soil (Kisvarda): open country soils belong to a large group which usually originates amid moderate rainy conditions. This is an older type of sandy soil which is richer in humus and more compact. It is of a crumbly texture and brown in color.

Properties: it has a medium absorption capacity and a moderate temperature fluctuation. (It is well suited for agricultural purposes).

Open country brick clay soils (Mezohegyes): this also belongs to the open country soil group, but it has a tighter texture. In quality it falls between sandy and clayey soils.

It resembles the previous soil in properties, but is temperature fluctuation is less because of its more compact condition.

In order to show the differences in temperature in different types of soil, we prepared three kinds of treatment. For a very general summary we have represented the monthly mean soil temperature graphically at four depths (2, 5, 10 and 20 cm) at six locations. Because of the complex plotting necessary, we are not presenting our graphs.

Mean Monthly Soil Temperature

2 cm Depth

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Sopronhorpács	0.4	0.2	5.4	11.1	16.4	22.1	20.1	21.7	16.7	12.3	7.5	3.7
Lengyel	0.7	1.2	6.7	12.7	16.2	23.1	22.3	22.7	17.1	13.0	8.2	3.9
Mezőhegyes	1.1	1.4	7.2	12.4	16.8	22.5	22.6	24.0	19.1	13.7	9.4	6.2
Baja	0.7	1.2	7.5	13.6	18.4	25.1	24.7	25.9	18.1	12.6	7.7	4.1
Kecskemét	-0.3	0.6	7.1	13.6	19.1	25.4	24.2	25.5	18.1	11.7	7.4	3.6
Kisvárda	-0.1	-0.6	6.8	11.4	16.5	21.1	21.9	22.3	16.6	12.5	8.3	4.9

5 cm Depth

Sopronhorpác	0.8	0.4	5.3	10.7	15.6	21.3	19.9	21.3	16.7	12.5	7.9	4.2
Lengyel	0.6	0.7	6.2	12.1	15.3	22.0	21.8	22.5	17.0	12.7	8.1	3.8
Mezőhegyes	0.8	0.9	6.6	11.6	16.1	21.7	21.8	23.2	18.3	13.1	9.0	5.7
Baja	0.8	1.3	7.5	13.7	18.2	24.8	24.2	25.8	18.2	12.8	7.9	4.3
Kecskemét	-0.4	0.3	6.8	13.3	18.5	24.5	23.2	24.8	18.0	11.9	7.6	3.8
Kisvárda	-0.2	-0.7	6.7	11.3	16.3	20.9	21.6	22.1	16.5	12.5	8.2	4.8

10 cm Depth

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Sopronhorpács	0.9	0.5	5.3	10.5	15.4	20.8	19.5	20.8	16.7	12.6	8.1	4.4
Lengyel	0.5	0.5	6.1	12.0	15.2	21.7	21.8	22.4	16.7	12.4	7.7	3.5
Mezőhegyes	1.1	0.6	6.2	11.4	15.8	21.2	21.5	23.0	18.4	13.0	9.1	5.8
Baja	-	-	7.5	13.8	18.3	24.6	24.3	25.9	18.8	13.3	8.4	4.7
Kecskemét	-0.4	0.3	6.7	13.2	18.2	24.1	22.7	24.5	18.1	12.0	7.8	4.0
Kisvárda	0.1	-0.7	6.4	11.2	16.2	20.7	21.7	22.0	16.9	12.6	8.6	5.0

20 cm Depth

Sopronhorpács	1.6	0.5	5.0	9.9	14.2	19.5	18.9	20.2	16.8	12.8	8.7	5.0
Lengyel	0.6	0.2	5.8	11.6	14.8	21.1	21.3	22.0	16.7	12.6	8.6	3.8
Baja	-	-	6.8	12.8	17.3	23.6	23.2	24.8	18.4	12.8	8.3	4.6
Kecskemét	0.2	0.4	6.6	12.7	17.3	22.7	21.6	23.4	18.2	12.5	8.6	4.8
Kisvárda	0.2	-1.0	5.5	10.6	15.4	20.3	19.5	21.3	16.6	12.2	8.4	4.9
Mezőhegyes	1.3	0.5	6.0	11.3	15.6	21.2	21.7	22.9	18.6	13.1	9.2	6.0

On the basis of the monthly temperatures we selected two months which we have graphically portrayed on the basis of mean daily data. In order to compare the daily temperature fluctuations, we drew a diagram prepared from the final data for each day without precipitation. Although this does not give us a true picture, because that would require maximum and minimum data, the difference between morning and noon temperatures brings us closer to a knowledge of the heat retention capacity for the different types of soil.

Before we present the data, we must again mention that, except for the two sandy soils, all of the soils are covered by turf where they were measured so we must be cautious with our statements.

Disregarding the summer months, it would not have been possible to show the few decimal point differences exhibited by the temperature of each kind of soil without a very great enlargement. The frozen January and February soil and the covering of snow do not disrupt the sequence of soil differences very much. On the other hand, with the approach of summer the soils gradually diverge and the differences corresponding to each type of soil become clear. At first the extremes are only a few decimal places apart, later in April they differ by a whole degree, and in June, July and August they are five or six degrees apart. The annual mean minimum sometimes appears in January, sometimes in February. The lowest temperatures measured in Mezohegyes, Baja, Lengyel and Kecskemet are found in the mean January temperatures, while the minimum for Sopronhorpacs and Kisvarda comes in February. The maximum monthly mean is found in August in nearly all places, although Sopronhorpacs hits its maximum in June.

While the monthly mean temperature rises gradually as summer approaches, we find a drop right in the middle of summer, in July. Perhaps we can attribute the cause of this to the summer, monsoon-type, rains. The drop is not found at the Mezohegyes and Kisvarda stations, on the two open country soils, and this cannot be explained by the properties of the two kinds of soil because identical phenomena are found in connection with the loosely textured sandy soils of Baja and Kecskemet, and with the extremely compact clayey soils of Sopronhorpacs and Lengyel.

The temperature changes originiating in the different soil textures in the places under investigation can be put into a sequence during the summer months. We find the greatest heating in Baja with a loose, windblown sand texture; the ventilation and the low moisture factor account for it. The Kecskemet sand, rich in humus and therefore more compact, shows a value lower by 0.5°, with differences of one to two degrees at deeper levels. The light reflection difference of the two sandy soils also contributes to this, since the darker colored soil of Baja warms up better than the dark brown Kecskemet soil. We find rather close values in open country and forest soil, with the sequence disturbed by the vegetative covering of the soil. This is shown most clearly by the Sopronhorpacs brick clay soil in spite of the sod: here warming is least, because the soil is the most compact. If we compare, for example, the mean of the sandy soils and the windblown sand for June, July and August, we find a difference of 4.6° between the two types of soil.

We find neither a sequence nor a difference in the temperature between types of soil in the mean for the early spring and later autumn months. This may be because the sunshine is considerably weaker during these months and the soil has a constant moisture content. The presence of moisture considerably moderates the warming and cooling of soils. This justifies the statement that the most decisive factor of soil temperature change is the moisture of the soil.

The second treatment, for which days of precipitation are graphed, also verifies this statement and we find that, while the daily mean temperatures on days of a month free of precipitation depart from the sequence to be expected from the soil texture, these differences fade considerably as a result of moisture content on days of precipitation.

In the third kind of treatment we compare the final daily data at depths of 2 and 20 centimeters for 19 May 1960 (Figure 1). In addition to the fact that both of these depths exhibit the above-mentioned sequence, we find, with due attention to the graphs of sandy and more compact soils, that the temperature variations are considerably greater in sandy soils than in more compact soils for measurements taken in the morning, at noon and in the evening. While the sandy soils have a morning and noon temperature differing by 12.5 and 10.0°C, the difference for more compact soils is 4.9 and 8.0°C. We find similar differences in the evening measurements.

In the deeper layers of soil, 20 centimeters, the maximum is found between the noon and evening measurements. The difference between the minimum and maximum shows the following sequence of soils: Baja 4.0, Kecskemet 3.9, Mezohegyes 3.0, Kisvarda 2.3, Sopronhorpacs 1.2 and Lengyel 1.0°C.

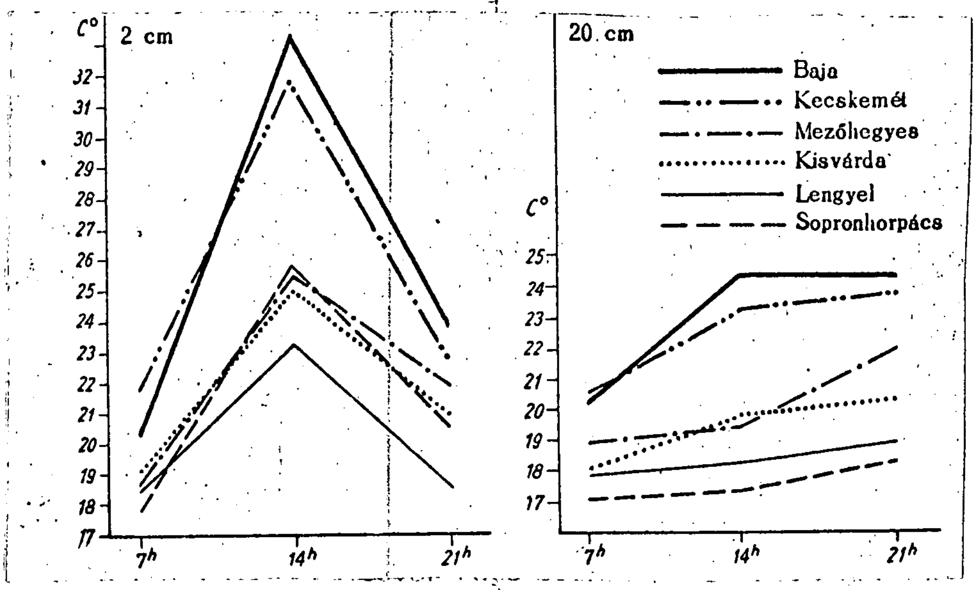

Figure 1. Soil Temperature Values on 19 May 1960

There would have to be greater differences between the more compact soils on every graph, since their textures are so different. Similar values should only be found, and are found, in the two open country soils. In addition, in many cases changes at the stations interrupt the theoretical sequence, but in all probability these can be attributed to the biological effect or to some peculiar composition. At certain times inversions are formed in various ways, because the vegetation sprouts at one place or another and thus produces a different shade effect.

On the basis of the above research it appears that we can a clear picture of a fairly large surface unit, and thus the temperature changes for the type of soil, if we carry out our measurements on bare ground.

Crop growers do not care how the temperature is formed under the vegetative covering, because they are growing agricultural crops. An investigation of biological effects would only be worthy of attention if we could separately measure ground covered with different kinds of vegetation; otherwise they would again only produce different temperature data.

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